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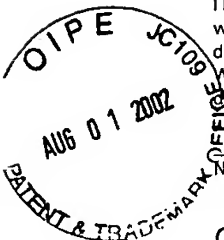
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EXPRESS MAIL CERTIFICATE

Date 8/1/02 Label No. EV 186683205-US

I hereby certify that, on the date indicated above, this paper or fee was deposited with the U.S. Postal Service & that it was addressed for delivery to the Assistant Commissioner for Patents, Washington, DC 20231 by "Express Mail Post Office to Addressee" service.

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D. Davis  
Name (Print)

D. Davis  
Signature

Customer No.:



07278

PATENT TRADEMARK OFFICE

Docket No.: 4634/OK253US0

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of: Adrian Lionel GRAY

Serial No.: 10/069,037

Art Unit:

Confirmation No.:

Filed: February 15, 2002

Examiner:

For: METALLURGICAL THERMOCOUPLE

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AUG 6 2002  
TC 2800 MAIL ROOM

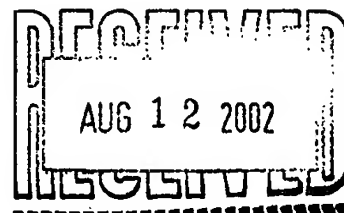
CLAIM FOR PRIORITY

Hon. Commissioner of  
Patents and Trademarks  
Washington, DC 20231

Sir:

Applicant hereby claims priority under 35 U.S.C. Section 119 based on

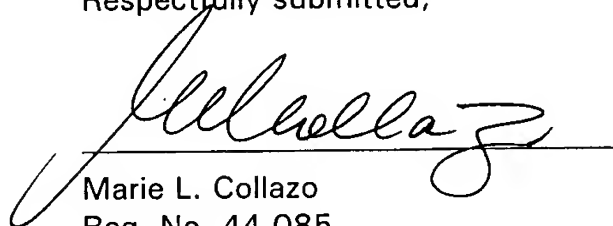
South African application No. 99/5203 filed August 16, 1999.



A certified copy of the priority document is submitted herewith.

Respectfully submitted,

Dated: August 1, 2002

A handwritten signature in cursive script, appearing to read 'Marie L. Collazo', written over a horizontal line.

Marie L. Collazo  
Reg. No. 44,085  
Agent for Applicant

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212-527-7700

Docket No. 4634/OK253US0

*Sertifikaat*

PATENTKANTOOR

REPUBLIC OF SOUTH AFRICA

DEPARTEMENT VAN

HANDEL EN NYWERHEID



*Certificate*

PATENT OFFICE

REPUBLIEK VAN SUID-AFRIKA

DEPARTMENT OF TRADE

AND INDUSTRY

Hiermee word gesertifiseer dat

This is to certify that



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The documents attached hereto, are true copies of the Application Form, Provisional Specification and Drawings of Patent Application No. 99/5203 filed in the name of TEMPERATURE MANAGEMENT SYSTEMS (PROPRIETARY) LIMITED on the 16th August 1999 and entitled "METALLURGICAL THERMOCOUPLE".

Geteken te  
Signed at

PRETORIA

in die Republiek van Suid-Afrika, hierdie  
in the Republic of South Africa, this

10th

dag van  
day of

July 2002



*[Signature]*  
Registrateur van Patente  
Registrar of Patents

FORM P1

REPUBLIC OF SOUTH AFRICA  
PATENTS ACT, 1978  
APPLICATION FOR A PATENT AND ACKNOWLEDGEMENT OF RECEIPT  
(Section 30(1) - Regulation 39)

15. 8. 99

JOHN & KERNICK

P.O. Box 351

HALFWAY HOUSE

INCOMST 3685

REPUBLIC VAN SUID AFRIKA

HAAR 376

The grant of a Patent is hereby requested by the undermentioned applicant(s) on the present application filed in duplicate

T440

21	01	Official Application No	22	Lodging Date	47	J & K Reference
		995203		16 August 1999		P 14027 ZA
71	Full name(s) of applicant(s)					
	TEMPERATURE MANGEMENT SYSTEMS (PROPRIETARY) LIMITED, a legal body organised and existing under the laws of the Republic of South Africa					
	Address(es) of applicant(s)					
	42 Ceramic Curve, Alton, Richards Bay, Kwa-Zulu Natal, Republic of South Africa					
54	Title of Invention					
	METALLURGICAL THERMOCOUPLE					

REGISTRAR OF PATENTS, DESIGNS,  
TRADE MARKS AND COPYRIGHT

1999 -08- 16

REGISTRATEUR VAN PATENTE, MODELLE,  
HANDELSMERKE EN OUTEURSREG

The applicant claims priority as set out in the accompanying form P2. The earliest priority claimed is

This application is for a Patent of Addition to Patent Application No.

This application is a fresh application in terms of S 37 and based on Application No.

This application is accompanied by:

- 1a A single copy of a provisional specification of 6 pages
- 1b Two copies of a complete specification of pages
- 2a Informal drawings of sheets
- 2b Formal drawings of 1 sheets
- 3. Publication particulars and abstract (form P8 in duplicate)
- 4. A copy of Figure of the drawings for the abstract
- 5. Assignment of invention (from the Inventors) or other evidence of title
- 6. Certified priority documents ( documents)
- 7. Translation of priority documents ( documents)
- 8. Assignment of priority rights
- 9. A copy of form P2 and the specification of S.A. Patent Application
- 10. A declaration and power of attorney on form P3
- 11. Request for ante-dating on form P4
- 12. Request for classification on form P9
- 13a Request for delay of acceptance on form P4
- 13b

24 01

21 01

21 01

74 Address for Service: JOHN & KERNICK, Midrand.

Date 16 August 1999

For the Applicant

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1999 -08- 16

REGISTRATEUR VAN PATENTE, MODELLE,  
HANDELSMERKE EN OUTEURSREG

REPUBLIC OF SOUTH AFRICA				REGISTER OF PATENTS				PATENTS ACT, 1978			
OFFICIAL APPLICATION NO.				LODGING DATE: PROVISIONAL				ACCEPTANCE DATE			
21	01	99/5203		22	16th August 1999			47			
INTERNATIONAL CLASSIFICATION				LODGING DATE: COMPLETE				GRANTED DATE			
5				23							
FULL NAME(S) OF APPLICANT(S)/PATENTEE(S)											
71	TEMPERATURE MANAGEMENT SYSTEMS (PROPRIETARY) LIMITED, a legal body organised and existing under the laws of the Republic of South Africa										
APPLICANTS SUBSTITUTED:								DATE REGISTERED			
71											
ASSIGNEE(S)								DATE REGISTERED			
71											
FULL NAME(S) OF INVENTOR(S)											
72	GRAY, Adrian Lionel										
PRIORITY CLAIMED			COUNTRY		NUMBER			DATE			
N.B. Use International abbreviation for country (See Schedule 4)			33		31		32				
TITLE OF INVENTION											
54	METALLURGICAL THERMOCOUPLE										
ADDRESS OF APPLICANT(S)/PATENTEE(S)											
42 Ceramic Curve, Alton, Richards Bay, Kwa-Zulu Natal, Republic of South Africa											
ADDRESS FOR SERVICE								J & K REF:			
74	JOHN & KERNICK, Waterfall Park, Midrand							P 14027 ZA			
PATENT OF ADDITION NO.				DATE OF ANY CHANGE							
61											
FRESH APPLICATION BASED ON				DATE OF ANY CHANGE							

**FORM P6**

**REPUBLIC OF SOUTH AFRICA  
PATENTS ACT, 1978**

**JOHN & KERNICK**  
P O Box 3511  
HALFWAY HOUSE  
1685

**PROVISIONAL SPECIFICATION**

(Section 30(1) - Regulation 27)

21	01	Official Application No	22	Lodging Date	47	J & K Reference
99/5203			16th August 1999		P 14027 ZA	
71	Full name(s) of applicant(s)					
TEMPERATURE MANAGEMENT SYSTEMS (PROPRIETARY) LIMITED, a legal body organised and existing under the laws of the Republic of South Africa						
72	Full name(s) of Inventor(s)					
GRAY, Adrian Lionel						
54	Title of Invention					
METALLURGICAL THERMOCOUPLE						

995203

- 2 -

## **METALLURGICAL THERMOCOUPLE**

### **FIELD OF THE INVENTION**

This invention relates to thermocouples and more particularly to thermocouples for use in determining the temperature of both solid and molten metals.

### **BACKGROUND TO THE INVENTION**

Many kinds of thermocouples have been designed and used for use in the metallurgical industry. In general in the melting and casting processes for the production of primary and secondary aluminium the use of so called "Marshall Tip Thermocouple" has become fairly standard practice. In the baking process or carbon anodes for the production of aluminium the use of wire and bead or mineral insulated thermocouples protected by special steel sheaths has become the norm.

In the ferrous metal industry platinum rhodium type thermocouples are used because the temperatures of molten steel are generally greater than those at which some of the components of the thermocouple used in the non-ferrous industry melt. It is difficult to provide insulation of the platinum rhodium element at molten steel temperatures for any length of time and insulation which will enable repeated use of the thermocouple is also difficult to provide. Consequently in the interests of economy, the thermocouple for this industry has been designed to protect the thermoelement for a maximum of about 4 minutes of immersion time, which is sufficient to obtain a single measurement.



Such thermocouples incorporate the smallest amount of the required materials, and where practical, the lowest cost materials in order to render the device expendable after only a single immersion into molten iron or steel.

Thus with an overriding cost consideration the different thermocouples have been developed to meet the particular requirements of particular applications.

There remains however the basic requirements for all thermocouples which is the integrity of the temperature measurement obtained. To achieve this it is necessary that the measuring probe be protected against electrical conductivity of its immediate protection material and further that a barrier of sufficient mechanical strength be provided against the inherently corrosive attack from the in situ environment in which the thermocouple is to be used.

#### **OBJECT OF THE INVENTION**

As stated the kind of thermocouple used in any application is driven by cost effectiveness per reading obtained. All of the thermocouples referred to suffer some or other disadvantage as a result of cost and it is the object of the present invention to provide a thermocouple which with minor modification can be used in the ferrous and non-ferrous industries and which can be made at a high cost effectiveness.

#### **SUMMARY OF THE INVENTION**

According to this invention there is provided a thermocouple comprising a length of mineral insulated thermocouple cable encased in refractory material housed in a metallic sheath.

Further features of this invention provide for the thermocouple cable to be type K or type W and for the metallic sheath to be of mild steel, any grade of stainless steel, Inconel or Nicrobel.

Still further features of this invention provide an inner metal tube around the thermocouple casing to contain the refractory material between the tube and the sheath and for a binder to be added to the refractory material to give it the required green strength. The inner tube will also usually be stainless steel.

The invention also provides for the refractory material to be acid, basic or neutral and consist essentially of alumina andalusite, magnesite, magnesia, rutile, silicon carbide, zircon, zirconia or compounds thereof and, when molten metal is the material of which the temperature is required, for the refractory to be matched to the aggregate used to line the molten metal containment vessel.

Yet further features of this invention provide for the refractory material to be consolidated between the inner tube and the sheath while maintaining its green strength and for the refractory material to be such that it will sinter in use.

The invention provides a method of shielding a thermocouple cable comprising locating beads of suitably bound refractory material between an inner tube and an outer stainless steel sheath and drawing the stainless steel sheath down to a predetermined size during which process the beaded refractory material is compacted between the tube and the sheath.

A further features of this method provides for the drawn sheath to be subsequently annealed and the refractory material to be sintered simultaneously with the annealing of the sheath.

#### **BRIEF DESCRIPTION OF THE DRAWINGS**

An example of this invention is described below with reference to the accompanying drawing which shows part of a length of thermocouple.

#### **DETAILED DESCRIPTION WITH REFERENCE TO THE DRAWINGS**

As illustrated the thermocouple (1) is made from a length of conventional thermocouple cable (2). This comprises an outer casing (3) of stainless steel around a magnesium oxide insulating body (4). An inner tube (5) is located around the outer casing (3) within an annular body of refractory material (6) contained in an outer metallic sheath (7). The inner tube and the sheath may both be made from stainless steel.

The refractory aggregate (6) may be chosen from any refractory such as alumina, andalusite, magnesite, magnesia, rutile, silicon carbide, zircon zirconia, and various compounds thereof. The aggregate may be acid, basic or neutral.

The encasing refractory is moulded within an outer sheath (5) of mild steel. Other metals such as any grade of stainless steel, Inconel or Nicrobel may be used for this sheath.

The refractory aggregate (6) must be bound to the inner tube (5) and the sheath (7) in a manner which provides sufficient strength throughout the temperature range in which the thermocouple is to operate.

Preferably the consolidation of the refractory material around the manganese oxide protected thermocouple cable is effected in the following way.

The refractory material (6) is bound into beads which are packed between the inner tube (5) or thermocouple cable casing and the outer sheath (7). The latter is then mechanically drawn down to the appropriate diameter for the final thermocouple. The beading of the refractory material provides an initial green strength to enable it to be conveniently handled.

Although the bead may be crushed and the bond destroyed during drawing, sufficient green strength arises from the great compaction which occurs, whilst the sintering properties of the refractory material remains intact.

The introduction of an inner tube provides flexibility in adapting the thermocouple produced to particular applications. The mineral insulated cable can be made longer than the sheath. This is often necessary. In addition, the one end of the sheath can be closed in the conventional manner and utilised as additional protection for conventional thermocouples made from the extended lengths resulting from the above described manufacture.

Where the thermocouple is to be used for measuring temperatures of non-ferrous metals the cable used will be type K. For use with ferrous metals the cable will be type W.

The binding of the refractory aggregate (6) moulded in a conventional metallic sheath (7) provides in use protection of the thermocouple cable from the corrosive nature of the target environment.

It should be noted however that for use in temperatures as low as 800° the strength of the refractory improves, as in situ sintering occurs.

This sintering of the consolidated refractory material further results, in high temperature applications of the thermocouple, in the sacrifice of the immersed part of the stainless steel sheath (7) to the in situ environment while nevertheless resulting in a residual monolithic shell of refractory material. This shell affords protection of the thermocouple cable from corrosive operating environment.

In this way all the handling and protective advantages afforded by the metallic sheath are retained, whilst the handling problems of the conventional ceramic sheath are avoided. Provided that the refractory aggregate is matched to the aggregate used to line the containment vessel, the best of both worlds is achieved. If for example, silicon carbide is used to line a given vessel, such as a launder or tundish, it follows that silicon carbide will be the best means of protecting the thermocouple in that vessel.

The flexibility of the thermocouple enables cost effectiveness under most conditions of use to be obtained. The final combination of outer sheath material and refractory aggregate depends entirely upon the target environment and thermocouple orientation, either vertical or horizontal.

In addition, the manganese oxide surrounds the thermoelement wire and so exposes only the surface of the ends of the two wires. In this manner, the rate of dissolution of the thermoelement into the target is reduced to an acceptable level. As a consequence, any length of the thermocouple shielded as above described becomes a thermocouple probe, and the need to form a junction between the two dissimilar metals becomes unnecessary.

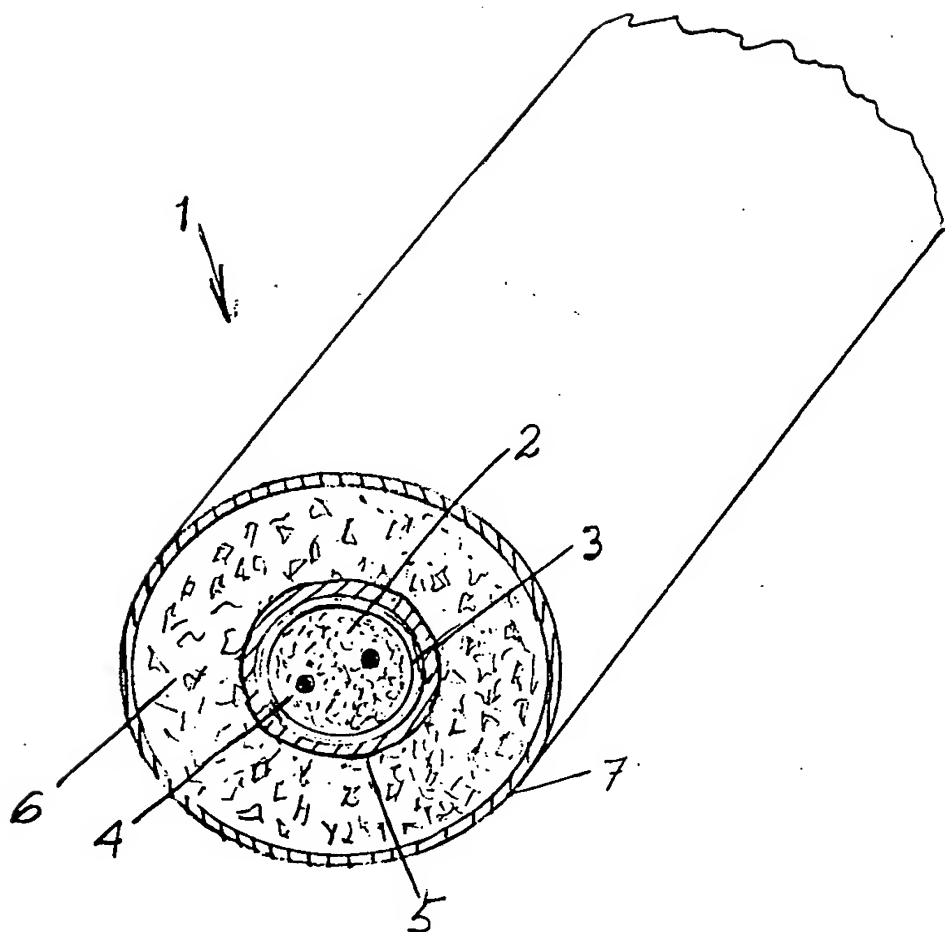
This thermocouple responds instantly when immersed into molten metal, or any electrically conductive compound which bridges the two wire ends. This provides temperature measurement of liquids as well as for solids to be obtained with the same thermocouple.

DATED THIS 16TH DAY OF AUGUST 1999



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JOHN & KERNICK  
FOR THE APPLICANT



~~JOHN & KERNICK~~  
For the Applicant